

LISTING OF CLAIMS

1. (Currently Amended) A process for removing a residue ~~residues~~ from a semiconductor substrate, comprising the steps:

providing a densified fluid ~~wherein said fluid~~ with a density above the critical density for said fluid ~~is a gas at standard temperature and pressure and wherein the density of the fluid is above the critical density;~~

~~providing a cleaning component;~~

intermixing said densified fluid and ~~said~~ a cleaning component comprising a reverse-micelle-forming surfactant and/or a reverse-micelle-forming co-surfactant and at least one agent chemically reactive toward said residue on said semiconductor substrate, said surfactants and said at least one agent in said fluid forming yielding a reactive cleaning fluid comprising reactive reverse-micelle(s) or and/or reactive aggregates operable for removing said residue from said substrate; and

contacting a said residue ~~on a substrate~~ with said reactive cleaning fluid [[:]]

whereby said residue is chemically modified and removed from said substrate.

2. (Cancelled).

3. (Currently Amended) The process according to ~~Claim 2~~ Claim 1, wherein said co-surfactants are selected from the group consisting of ~~comprise~~ alkyl acid phosphates, alkyl acid sulfonates, alkyl alcohols, substituted alkyl alcohols, perfluoroalkyl alcohols, dialkyl sulfosuccinates, bis-(2-ethyl-hexyl) sulfosuccinates, AOT, ~~sodium AOT~~,

~~ammonium AOT, derivatives thereof, salts thereof, or~~ and combinations thereof.

4. (Currently Amended) The process according to ~~Claim 2~~ Claim 1, wherein said co-surfactants comprises a non-CO₂-philic surfactant and a CO₂-philic surfactant.

5. (Currently Amended) The process according to Claim 1, further comprising the step of rinsing said substrate with a densified ~~rinsing~~ fluid comprising up to about 30% modifiers by volume.

6. (Currently Amended) The process according to Claim 5, wherein said densified ~~rinsing~~ fluid is a pure densified fluid absent any added modifiers.

7. (Currently Amended) The process according to Claim 5, wherein said densified ~~rinsing~~ fluid is a mixture of densified CO₂ and a modifier selected from the group consisting of isopropyl alcohol, H₂O, methanol, ethanol, ~~or~~ and combinations thereof.

8. (Currently Amended) The process according to Claim 7, wherein said densified ~~rinsing~~ fluid comprises up to about 15% by volume isopropyl alcohol.

9. (Currently Amended) The process of Claim 1, wherein said densified fluid is a liquid ~~with~~ having a temperature in the range from about 20 °C to about 25 °C, a pressure from about 850 psi to about 3000 psi, and a density above a critical density for ~~the~~ said densified fluid.

10. (Currently Amended) The process according to Claim 1, wherein ~~said~~ the chemical modification of said residue comprises at least one reaction selected from the group consisting of chemical, oxidation, reduction, molecular weight reduction, fragment cracking, exchange, association, dissociation, or combinations thereof whereby dissolution, solubilization, complexation, or binding of residues occurs whereby said residues are removed from said substrate.

11. (Previously Presented) The process according to Claim 1, wherein said reactive cleaning fluid has a reduced density in the range from about 1 to about 3.

12. (Original) The process according to Claim 1, wherein said reactive cleaning fluid has a temperature and pressure above the critical temperature and critical pressure of said densified fluid.

13. (Currently Amended) The process according to Claim 1, wherein said densified fluid is ~~a member~~ selected from the group consisting of carbon dioxide, chlorodifluoromethane, ethane, ethylene, propane, butane, sulfur hexafluoride, ammonia, and combinations thereof.

14. (Currently Amended) The process according to Claim 1, wherein said reverse micelle forming surfactant is ~~a member~~ selected from the group consisting of CO₂-philic, anionic, cationic, non-ionic, zwitterionic, and combinations thereof.

15. (Currently Amended) The process according to Claim 14, wherein said anionic reverse-micelle forming surfactant is selected from the group consisting of PFPE surfactants, PFPE carboxylates, PFPE sulfonates, PFPE phosphates, alkyl sulfonates, bis-(2-ethyl-hexyl) sulfosuccinates, sodium bis-(2-ethyl-hexyl) sulfosuccinates, ammonium bis-(2-ethyl-hexyl) sulfosuccinates, fluorocarbon carboxylates, fluorocarbon phosphates, fluorocarbon sulfonates, and combinations thereof.

16. (Original) The process according to Claim 14, wherein said cationic reverse-micelle forming surfactant is selected from the tetraoctylammonium fluoride class of compounds.

17. (Original) The process according to Claim 14, wherein said non-ionic reverse-micelle forming surfactant is selected from the poly-ethyleneoxide-dodecyl-ether class of compounds.

18. (Original) The process according to Claim 14, wherein said zwitterionic reverse-micelle forming surfactant is selected from the alpha-phosphatidyl-choline class of compounds.

19. (Currently Amended) The process of Claim 1, wherein said at least one agent ~~reactive chemical agent~~ is selected from the group consisting of mineral acids, fluoride-containing compounds and acids, organic acids, oxygen-containing compounds,

amines, alkanolamines, peroxides, chelates, ammonia, and combinations thereof.

20. (Previously Presented) The process according to Claim 19, wherein said mineral acids are selected from the group consisting of HCl, H₂SO₄, H₃PO₄, HNO₃, HSO₄⁻, H₂PO₄, HPO₄²⁻, phosphate acids, acid sulfonates, dissolution products thereof, salts thereof, and combinations thereof.

21. (Previously Presented) The process according to Claim 19, wherein said fluoride-containing compounds and acids are selected from the group consisting of F₂, HF, dilute HF, ultra-dilute HF, and combinations thereof.

22. (Previously Presented) The process according to Claim 19, wherein said organic acids are selected from the group consisting of sulfonic acids, phosphate acids, phosphate esters or their salts, substituted derivatives thereof, and combinations thereof.

23. (Currently Amended) The process according to Claim 19, wherein said oxygen-containing compounds are selected from the group consisting of O₂, ozone, functional or reactive equivalents, and combinations thereof.

24. (Original) The process according to Claim 19, wherein said alkanolamine is an ethanolamine.

25. (Original) The process according to Claim 19, wherein said amine is hydroxylamine.

26. (Currently Amended) The process according to Claim 19, wherein said ~~chelate~~ chelating agent is ~~a member~~ selected from the group consisting of pentanediones; 2,4 pentanediones; phenanthrolines; 1,10 phenanthroline; EDTA, sodium EDTA, oxalic acid, ~~or~~ and combinations thereof.

27. (Original) The process according to Claim 19, wherein said peroxides are selected from the group consisting of organic peroxides, alkyl peroxides, t-butyl peroxides, hydrogen peroxide, substituted derivatives, and combinations thereof.

28. (Currently Amended) The process in accordance with Claim 1, wherein said reactive cleaning fluid comprises up to about 30% by volume of said at least one agent ~~reactive reagents and/or modifiers~~.

29. (Currently Amended) The process in accordance with Claim 28, wherein said reactive cleaning fluid comprises from about 2% to about 5% modifiers by volume selected from the group consisting of including PFPE acid phosphates, AOT, salts thereof, H₂O, ~~or~~ and combinations thereof.

30. (Currently Amended) The process in accordance with Claim 28, wherein said reactive cleaning fluid comprises from about 3% to about 5% modifiers by volume

selected from the group consisting of including PFPE carboxylate, alkanolamines, hydroxylamine, H₂O, ~~or~~ and combinations thereof.

31. (Previously Presented) The process in accordance with Claim 28, wherein said reactive cleaning fluid further comprises a corrosion inhibitor having a concentration in the range from about 0.1% to about 1% by volume.

32. (Previously Presented) The process in accordance with Claim 31, wherein said corrosion inhibitor is selected from the group consisting of benzotriazoles; 1,2,3-benzotriazole; catechols; catechol; 1,2-di-hydroxy-benzene; 2-(3,4-di-hydroxy-phenyl)-3,4-di-hydro-2H-1-benzopyran-3,5,7-triol, substituted derivatives thereof, and combinations thereof.

33. (Currently Amended) The process according to Claim 28, wherein said reactive cleaning fluid ~~further~~ comprises about 5% modifiers by volume selected from the group consisting of including PFPE carboxylates, amines, alkylamines, hydroxylamines, benzotriazoles, catechols, and combinations thereof.

34. (Previously Presented) The process of Claim 1, wherein said contacting comprises a contact time with said reactive cleaning fluid of about 15 minutes.

35. (Previously Presented) The process of Claim 1, wherein said contacting comprises a contact time with said reactive cleaning fluid of less than about 5 minutes.

36. (Original) The process of Claim 1, wherein said residue is selected from the group consisting of organic residues, metal residues, etch residues, non-metal residues, polymeric residues, and combinations thereof.

37. (Original) The process of Claim 1, wherein said residue is a transition metal.

38. (Original) The process of Claim 1, wherein said residue is selected from the group consisting of Cu, Al, Fe, Ta, and combinations thereof.

39. (Previously Presented) The process of Claim 1, wherein said reactive cleaning fluid has a temperature in the range from about 20 °C to about 25 °C, a pressure in the range from about 850 psi to about 3000 psi, and a fluid density above the critical density of the densified fluid.

40. (Previously Presented) The process of Claim 1, wherein contacting of said residue with said reactive cleaning fluid is preceded by etching of said substrate.

41. (Previously Presented) The process of Claim 1, wherein said process is applied in manufacturing of a semiconductor substrate.

42. (Previously Presented) The process of Claim 41, wherein manufacturing of said substrate or wafer further comprises a processing step selected from the group

consisting of etching, residue removing, cleaning, transferring, rinsing, depositing, and combinations thereof.

43. (Previously Presented) The process of Claim 42, wherein said transferring comprises moving said substrate or wafer with a transfer system or device during manufacturing of said wafer.

44. (Previously Presented) The process of Claim 42, wherein depositing comprises deposition of a material to said substrate or wafer selected from the group consisting of metals, non-metals, silicon, films and layers thereof, or combinations thereof.

45. (Previously Presented) The process of Claim 1, wherein contacting of said residue with said reactive cleaning fluid comprises applying said fluids in conjunction with a fluid delivery system or device.

46. (Previously Presented) An apparatus, comprising:

a cleaning vessel or chamber operably disposed to receive a semiconductor substrate or wafer and a reactive cleaning fluid therein, said cleaning fluid comprising reactive reverse-micelle(s) or reactive aggregates formed by intermixing of a densified fluid and a cleaning component, wherein said densified fluid is a gas at standard temperature and pressure and the density of the densified fluid is above the critical density for said densified fluid;

delivery means for applying said reactive fluid to said wafer in said vessel or

chamber; and

whereby when contacting said residue on said substrate or wafer in said chamber or vessel with said reactive cleaning fluid said residue is chemically modified and removed from said wafer or substrate.

47. (Previously Presented) The apparatus of Claim 46, wherein said cleaning component comprises at least one member selected from the group consisting of reverse micelle-forming surfactants, reverse micelle-forming co-surfactants, reactive reverse micelle-forming surfactants or reactive reverse micelle-forming co-surfactants, reactive chemical agents, and combinations thereof.

48. (Previously Presented) The apparatus of Claim 46, wherein said delivery means for applying said reactive cleaning fluid is a delivery system or device.

49. (Previously Presented) The apparatus of Claim 48, wherein said delivery system or device further comprises a pumping system or device for delivering said cleaning fluid.